

On a Possible Case of Mimicry in the Common Sole.

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THERE are two common species of Weever (*Trachinidæ*) found in British waters, namely, the Greater Weever (*Trachinus draco*) and the Lesser Weever (*Trachinus vipera*). Both are venomous, and the poison is concentrated at the spines of the first dorsal fin and the opercular spine in its immediate neighbourhood.

The habits of *T. vipera* are the better known. On all occasions it attempts to bury itself in the sand until only the top of its head, with eyes and mouth, and dorsal fins are above the surface. In this position it apparently lies in wait for the shrimps and small fry which form its food. As a probable adaptation to this habit, the eyes and mouth of the fish are elevated into a dorsal position, so that the least possible surface of the body need be exposed above the sand.

The habits of *T. draco* are closely similar. It is abundant off the coast of Norway, and on occasions it is taken in great shoals. Of its habits Professor Smitt remarks * :—

“The Great Weever lives in water of a moderate depth with a sandy bottom. It buries itself in the sand and keeps in hiding, in order more suddenly to attack its prey, which consists of small fishes and crustaceans.”

In British waters *T. draco* is found further off-shore and in deeper water than *T. vipera*. The experience of our trawlers in the Southern North Sea and in the English Channel is that *T. draco* is found in greatest abundance on the off-shore trawling-grounds, whilst *T. vipera* occurs most frequently close inshore in sandy bays. *T. draco* “occurs along the whole west coast (of Norway) from Bergen in Norway to the south of Scania, and into the Baltic as far as the coast of Prussia, where it is, however, extremely rare.” † “To the south it is common as far as the Mediterranean and the Black Sea.” †

T. vipera is very abundant in the English Channel and the North Sea, but Smitt describes only a single specimen from the coast of Norway. In British waters, especially towards the north, it is more common than *T. draco*. Like the latter, it is often found in large shoals.

In both species the first dorsal fin has six (occasionally seven in *T. draco*, according to Krøyer ‡, who remarks that seven spines are common in the males) sharp strong spines or rays, with a conspicuous black membrane. Upon provocation this fin is erected and spread out in the most conspicuous manner. Its intense black colour, in contrast with the pale yellow and brown tints of

* ‘Scandinavian Fishes,’ Part i. p. 131.

† *Loc. cit.* p. 130.‡ *Cf.* Canestrini, ‘Fauna d’Italia.’

the fish and with the light drab of the sand, makes it clearly visible from a considerable distance. It has been suggested by Garstang that this is a case of warning coloration. Considering the poisonous nature of the fish and its abundance, one cannot doubt that this black danger signal must act as a powerful deterrent to its enemies*. If this is the case, the habit of aggregation into large shoals would be beneficial through accumulative warning action.

The right or upper pectoral fin of the Common Sole (*Solea vulgaris*) is well developed, and the upper half of the fin has a large, deep black patch. This patch is, as remarked by Smitt, more conspicuous in the young Sole than in the adult, but it is a clearly recognizable feature throughout life, except in the very earliest stages. When a number of Soles are displayed in the market, the little black dot in the pectoral region of each fish can be seen at some considerable distance.

The habitat of the Sole is well-known. "The usual depth at which Soles are found is from 20 to 30 fathoms, but it may exist at greater depths; it probably does not extend beyond 100 fathoms. Adult Soles may occur at any depth less than 20 fathoms; but usually in shallow water, less than 10 fathoms deep, only young individuals are found" †.

Cunningham goes on to describe the habit of the Sole of burying itself in the sand and instinctively going through the motion of doing so when placed upon the bare floor of a tank. "Usually when resting undisturbed beneath the sand or gravel it leaves its eyes uncovered, and these can be detected by careful search."

The smaller fry of Soles, like the Lesser Weever, are commonly found on the shallow sandy flats worked by shrimp-trawls.

The Sole therefore resembles the Weevers in the soft or sandy nature of the ground frequented by it, in the depth of water, and in the habit of concealing itself under the sand.

The general distribution of the Sole is well-known. It occurs in small numbers off the coasts of Norway, and only ranges to 62° N. (Collett). It is scarce in the Baltic, though found in more abundance in the Skager-Rak and the Skaw. In the southern half of the North Sea, as represented by a line from Flamborough Head to the Naze, it is common, but is found in greatest abundance in the English and Bristol Channels. It ranges southwards along the Atlantic seaboard of Morocco and into the Mediterranean. It is found off the coast of Scotland, but is not a common fish north of Berwick.

The suggestion here made is that the black patch of the pectoral fin in the Sole is a case of mimicry in relation to the black dorsal fin of the Weever.

* Poulton, 'Colours of Animals,' p. 164; Camb. Nat. History: Fishes, &c. p. 174.

† 'The Sole,' Cunningham, p. 101.

With the above facts already known, I have attempted to obtain further evidence, confirmatory or otherwise, of this theory, by observation of the habits of the Sole. The process of burying is effected in the case of the Sole by an undulating motion of the dorsal and anal fins. Each fin is thrust outwards and downwards into the sand, some of which is at the same time thrown on to the back of the fish.

In the Lesser Weever, the body of the fish works its way down into the sand by side-to-side undulations of the hinder half of the body, and especially the caudal fin. The pectoral fins also largely assist by a process of scooping into the soft sand. In both Sole and Weever the process is very rapidly and effectively carried through, and in both the motions are performed even if no sand be present.

On the approach of an enemy it is the usual habit of the Plaice, the Turbot, the Sole, and some other flat-fish to lie concealed on or in the sand or loose gravel. This is persisted in until the psychological moment when the fish is apparently convinced that its presence is known to the enemy and that further concealment is useless. The property of the skin of flat-fish to modify its coloration in accordance with the conditions of light assists immensely the power of concealment; and it is further helped in varying degree by a persistent capacity for remaining motionless which, when highly developed, becomes a habit of simulating death. So far as one can judge by specimens which have been for some years in the aquarium tanks, I find that the Turbot and the Plaice "bolt" first, the Sole next, and the Sand-Sole (*S. lascaris*) appears to carry the habit of quiescent lying in the sand to the extreme of actually simulating death.

But whenever the fish is aroused and seeks refuge in flight, there is a marked difference in the behaviour of these species. In the Turbot and the Plaice, there is a general scurry in which the pectoral fins are seen to take part by quick striking movements, no doubt assisting to raise or depress the head. In the Sole, on the contrary, the upper pectoral fin is erected sharply and spread, either just before "bolting" or immediately thereafter, and, as a rule, it is not employed as a motor-fin. It forms a motionless black flag held up conspicuously like that of the Weever, and with exactly the same menacing attitude. There are at the Plymouth Laboratory several large Soles which have been five years in the tanks, and it is remarkable to observe how, when they have been disturbed, they sail around with the little pectoral fin held stiffly erect. Further than this, the fin is held up with its plane lying in the central plane of the fish, though the natural position is perpendicular to this plane. It is difficult to account for this very marked and persistent habit in any other way than as a case of mimicry.

The Dab (*P. limanda*) and, to some extent, the Flounder (*P. fesus*) have also a habit of holding their upper pectoral fins erect. In the former the

pectorals are perhaps better developed than in any other British flat-fish. They are put to active use in swimming, but when a Dab is about to alight on the sand, and its body is descending at an angle to the ground, it very commonly holds the upper pectoral fin stiffly erect, possibly for the purpose of guiding its descent.

The Soles, as a family, have a characteristically elongated body. The dorsal and anal fins are extended along its whole length and are specialized as a means of locomotion. Probably in correlation with this feature the family has a marked reduction in proportionate size of the pectoral fins as compared with the Pleuronectidæ, and the various subfamilies exhibit varying stages of degeneration of these fins. They have been classified in accordance with this feature. In the group of *Monochires* there is only one pectoral fin, the right or upper. (*Solea monochir* of the Mediterranean.)

In the *Microchires*, represented in British waters by the Thickback (*Solea variegata*) and the Solenette (*Solea lutea*), both pectoral fins are present, but they are vestigial. They can be of little or no use for swimming purposes. In the Solenette the right pectoral is often of a brownish tint, but I have never seen it of the conspicuous black hue as shown in the figure by Couch. In *S. variegata* the upper pectoral is inconspicuous and of the same tint as the surface of the body.

In the Sole (*Solea vulgaris*) and the Sand-Sole (*Solea lascaris*) the pectorals are comparatively well developed. In the latter the black patch varies greatly, from two or three black streaks or spots to a sharply-defined black blotch. There appears to be some difference of opinion as to the black patch upon the right pectoral of *Solea lascaris*. Couch is very decisive upon the point in text and figures. Day figures and describes a black patch with a white border. Cunningham remarks in his text that the black patch is present, but shows little trace of it in his excellent figure. An enquiry upon this point indicates that whilst the black patch of the Sole is very conspicuous when the fish is at rest, that of the Sand-Sole is largely if not entirely hidden by the partial closing of the fin. In Cunningham's figure the fin is shown in the closed condition and the black patch is scarcely recognizable.

There are half-a-dozen Sand-Soles in the Plymouth Laboratory which have resided in the tanks for two years or more. They show a right pectoral of the same uniform tint as the rest of the body but with a few black streaks. The coloration in this case may have undergone considerable change. According to Moreau, the pectoral is "jaunâtre ou grisâtre à la base et sur les côtés, blanche à l'extrémité; elle est marquée dans sa partie moyenne et postérieure d'une tache noire, arrondie, bien circonscrite" *.

Similarly Dr. Günther † describes the Channel Lemon Sole, under

* 'Poissons de la France,' Part iii. pp. 309-310.

† British Museum Catalogue, vol. iv. p. 467.

S. aurantiaca, as having a "pectoral with an ovate black spot on its hinder half." In *S. lascaris*, from the Madeiras and Mediterranean, he describes "a black ocellus edged with yellow on the extremity of the lower half of the pectoral." This description applies equally to his two species, *S. impar* and *S. margaritifera*.

According to Moreau and Cunningham, Günther's *S. aurantiaca* is identical with *S. lascaris* of the Mediterranean Sea. There is another species (*Solea melanochira*, Moreau *) found in the Mediterranean which has the upper pectoral considerably developed. This fin is of an intense blue-black with a whitish border. The fin is long and is borne upon a peduncle. In varying degree the blackish tint of the upper pectoral seems to be characteristic of the Soles proper, and is not found in the *Microchires* or *Monochires* nor in other Pleuronectidæ. If the inference is correct that the preservation of the pectorals in the Soles proper may be due to their employment as imitation danger-signals, it might be conjectured that the hypertrophy of the pectorals in *Solea melanochira* is traceable to a similar function, even more conspicuously developed.

In *S. vulgaris* the black spot always has a definite relation to the anterior border of the fin, extending backwards from its edge; in *S. lascaris* the spot at most just touches its border with its circumference and usually does not reach so far.

In estimating the probability of these black fins of the Soles owing their existence to the phenomenon of mimicry, the mimicked forms being, in this instance, the Trachinidæ, we have to consider:—

(1) That the geographical distribution of *Solea vulgaris* and its nearest allies is closely similar to, if not identical with, that of the two common species of *Trachinus*.

(2) That the sand-loving and sand-hiding habits of the two forms are closely similar, and that they actually inhabit the same grounds, the young Soles with *T. vipera* and the adults in deeper water with *T. draco*.

(3) That on disturbance each type holds its black fin erect in a menacing manner; that of the Sole is held at right angles to the normal position for Pleuronectidæ.

(4) That the pectoral fin of other Pleuronectidæ, or even Soleidæ, is not coloured black, and is not held erect in the same manner.

The use of black as a warning colour is significant. In land animals we are familiar with black, combined with red or yellow, being employed for this purpose, but the general facts of marine coloration seem to show that red or yellow are, in the presence of reddish tints on sea-floor and amongst seaweeds and zoophytes, colours of concealment rather than the reverse.

* Revue et Magasin de Zoologie, 1874, t. xi. p. 115.

With the prevailing greens and blues of the transmitted light there remains little else than intense black, contrasted with a light background, to serve for warning or recognition marks.

There is a common littoral fish (*Uranoscopus scaber*), a member of the same family as *Trachinus*, found in the Mediterranean Sea. Its habits, as regards burying itself in the sand, appear to be closely similar to those of the *Trachini* and it has an erectile first dorsal fin of a jet-black colour. There is a formidable spine on the operculum, and this fish, like *Trachinus*, is said to be poisonous. It inhabits the same grounds as *Trachinus*, and a black or black-and-white first dorsal fin appears to be as characteristic of the genus *Uranoscopus* as it is of the genus *Trachinus*. It is difficult not to conclude that it obtains a considerable amount of protection by possessing a conspicuous black dorsal fin, and that its close resemblance to *Trachinus* may be of mutual service to both kinds of fish.

On the other hand, it seems a general rule that in sand-loving round fishes, whatever colour-markings may be necessary tend to become concentrated in the dorsal fin, which alone is visible when the fish is buried in sand (*cf.* Gobiidæ, Centronotidæ, &c.).

Notes on some Freshwater Sponges collected in Scotland. By
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As the local records of freshwater sponges in Scotland appear to be neither numerous nor altogether trustworthy, I have thought it worth while to publish the following notes, which are based on specimens submitted to me by Sir John Murray and Mr. W. Evans and on others found by myself during a recent visit to Scotland. I do not think it probable that the two species here recorded exhaust the list of those that occur, but few naturalists have taken the trouble to collect the Spongillinæ of Great Britain, which are therefore imperfectly known. Several interesting forms will probably be discovered in the lakes of Scotland and England if stones from the bottom are examined. So far as my own experience in Scotland and India goes, the under surface of stones from lakes is a favourite station for the less conspicuous and smaller species, which are in many respects the most interesting. These are not always easy to distinguish at sight from patches of algæ, but their gritty constitution, due to the spicules of which their